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THE PINK BOLLWORM, PECTINOPHORA GOSSYPIELLA

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INTRODUCTION

The pink bollworm (*Gelechia*) *Pectinophora gossypiella* Saunders,[2] is one of the most destructive cotton insects known and ranks among the half-dozen most important insect pests of the world. It occurs in the cotton districts of Asia, Africa, and the Hawaiian Islands, its ravages in these regions amounting to more than those of all other cotton insects combined. The pink bollworm repeatedly reduces the yield of lint 50 per cent or more and materially lessens the amount of

[1] While assuming full responsibility for the observations here recorded, the writer wishes to acknowledge that he has gathered many suggestions from the work of previous students and especially from Dr. D. T. Fullaway, who during the early part of the writer's stay in Honolulu gave him the benefit of his intimate acquaintance with the insect in the field. To Mr. C. E. Pemberton the writer is indebted for painstaking and laborious monthly examinations of many thousands of seeds, continuing after the writer's departure from Honolulu an experiment with the caterpillars in stored baled cotton for the purpose of ascertaining their longevity under such conditions. To Prof. J. F. Rock, of Honolulu, the writer is indebted for all plant identifications and for helpful information about localities of some of the rarer malvaceous plants in the Hawaiian Islands, which it was desirable to investigate as possible food plants of the pink bollworm. The identifications of the parasites are to be credited to Messrs. S. A. Rohwer, J. C. Crawford, and A. A. Girault. The writer wishes especially to acknowledge his obligations to Mr. Carl Heinrich and to Dr. Adam Böving, both of whom have given much assistance during the preparation of the systematic part of this paper. With the exception of figure C, Plate 9, which was drawn by Dr. Böving, the illustrations have all been made under the writer's direction by Mr. H. B. Bradford, and much credit is due him for his painstaking work, which greatly enhances the value of the paper.

[2] The species has been placed by European specialists in the genus Gelechia, but it is very distinct from this genus both in the imago and as larva and pupa. A new genus is here characterized for it and for the closely related *P. malvella* Zeller, the larva of which feeds in the seeds and capsules of althea and malva in Europe.

oil obtained from the seeds (10, 12, 37).[1] The minimum yearly loss from this insect in Egypt is estimated at 10 per cent of the value of the crop, but normally much more damage is done by it. Maxwell-Lefroy states (20) that the minimum loss in India is more than $10,000,000 annually. In the Hawaiian Islands the cultivation of cotton has practically been abandoned on account of this pest, which during 1915 infested from 50 to 99 per cent of the bolls in the few fields yet remaining and destroyed from one-half to nine-tenths of the lint.

Similar damage would undoubtedly result if the insect by any accident should be established in the cotton areas of the United States, and it would be difficult to overestimate the importance of guarding against such introduction (32). The pest might easily prove even more serious than the cotton boll weevil, and it would certainly effect enormous annual losses.

Very fortunately this insect has not yet become established in the United States. The regulations of the Federal Horticultural Board in requiring the fumigation of all foreign cotton have reduced to a minimum the danger of its introduction from abroad. Similar precautionary measures unfortunately have not been taken in time by the neighboring Republic of Mexico, nor in South America, and it has been discovered recently that the pink bollworm has been introduced accidentally into both Mexico and Brazil within the last few years through cottonseed importations from Egypt and has become established in important cotton regions of these countries.

Up to 1912 the Brazilian cotton crop was free from any serious insect depredators. During the next two years large importations of Egyptian cottonseed were made for the purpose of improving the grades of cotton and this seed was distributed free to cotton producers without previous fumigation, with the result that the pink bollworms present in the Egyptian seed were thoroughly scattered over and established in all the cotton regions in Brazil during 1915. During the following year the pest caused a loss of 50 per cent of the cotton crop in some localities. This accidental introduction of the pink bollworm can never be remedied and will effect a perpetual diminution of the resources of Brazil. By the application of the present scientific knowledge of the insect and of the crop, cultural methods can probably be evolved and effective parasites possibly may be introduced which together will make cotton remain a profitable crop in Brazil, but the pink bollworm will continue to cause a very material reduction in the profits in spite of any measure which may be taken against it. This calamity could have been prevented by a properly enforced regulation, such as we have in the United States, covering the importation of cottonseed and requiring the fumigation of all imported seed.

[1] Reference is made by number to "Literature cited," p. 366-370.

It has not been possible to ascertain how widely distributed the pest has become in Mexico beyond the Laguna district near San Pedro, where it is already a serious pest, but its presence there constitutes a very grave menace to our cotton fields. When it is considered that the introduction of this insect into American cotton fields would mean a permanent annual loss of millions of dollars to the United States, it becomes evident that all possible precautions should be taken to prevent or delay its arrival.

An essential step toward this end is a thorough knowledge of the insect in all its stages which will enable its prompt recognition in any stage, even from fragments, by the agents employed to prevent its introduction. The detailed description given in this paper provides this means of identification. It is based on an investigation of its life history and habits, conducted in the Hawaiian Islands during the summer of 1915 and subsequent anatomical studies made from material from various sources.

There is added to the paper a similar detailed descriptive and anatomical study of another lepidopterous insect, *Pyroderces rileyi* Walsingham, which may be called the "scavenger bollworm" because it frequently occurs in decayed or dried bolls injured by other insects. It seems desirable to include this supplemental study of *Pyroderces rileyi*, which frequently has been and may be mistaken for the pink bollworm. The anatomical details given in this paper will make it possible for the inspector to distinguish readily these two insects.

ORIGINAL HOME AND PRESENT RANGE

Although the species was first noticed and described from India, it is not probable that India is its original home.

Saunders expressed the belief, in his description of the species (1, 2), that the pink bollworm was imported into India with American cotton, which it preferred to the Indian varieties of Gossypium. If so introduced into India it was probably with the seed of some American variety of cotton grown in some part of Africa. Other early East Indian records have been traced by Durrant (26) to Egyptian cottonseed, and Africa is, from all the evidence on hand, apparently the original home of *P. gossypiella*. The occurrence there as well as in southern Europe of the only other known species (*P. malvella* Zeller) of the genus Pectinophora is in itself a strong support for the theory of African origin.

The species has spread to most, if not all, the cotton districts in Africa, Asia, Japan, Ceylon, Straits Settlements, Philippines, and Hawaiian Islands; and within the last few years it has been brought to the American continent and is already established in Brazil and Mexico (3, 4, 13, 14, 15, 20, 21, 22, 23, 25, 26).

This nearly cosmopolitan distribution leaves the United States practically the only large cotton-producing country free from the pest, and

it emphasizes the importance of maintaining for our country this enormous advantage over the rest of the world in the matter of cotton production.

HOW TO DISTINGUISH THE PINK BOLLWORM IN THE FIELD

Definite and final determination of *P. gossypiella* in any stage can be made only by the aid of the microscope; and, unless a collector or inspector is thoroughly familiar with the species, all suspected material should be sent at once to the Bureau of Entomology for determination. Even a fraction of the insect in any of its stages can be recognized under the microscope by the characters given in succeeding sections of this paper.

The following essential characters, all of which can be discerned by the aid of a common pocket lens, will enable the practical worker to make a reasonably certain preliminary determination of the insect in all its stages in the field.

If a small dark-brown moth is caught in the cotton field or in a cotton mill or warehouse and is found to have the forewings pointed and the hindwings broad and sinuated below the tip and to possess long curved palpi and long stiff hairs on the first antennal joint, it is reasonably certain that the moth is *P. gossypiella*, the adult of the pink bollworm (Pl. 7, *A*).

If, within the cotton boll or associated with stored cottonseed, a small white or pinkish caterpillar with brown head is found and under a hand lens the mandibles are seen to have four teeth (Pl. 10, *D–G*) and the crotches on the abdominal prolegs form a partial circle or horseshoe, opening outwards (Pl. 10, *K*), the caterpillar will most probably prove to be the pink bollworm.

Again, if, within a cotton boll or otherwise associated with cotton in the field or in the mill, a small lepidopterous pupa is found, which under the lens is found to be entirely covered with a short velvety pubescence and to possess a short, curved, upturned hook at the posterior end (Pl. 12, *A–D*), it may with considerable certainty be determined as a pupa of the pink bollworm.

GENERIC DESCRIPTION

PECTINOPHORA, new genus (Gelechiidae).

Type: *Gelechia gossypiella* Saunders.

MOTH.—Face and head smooth. Labial palpi long, recurved, reaching above vertex; second joint thickened on the underside with slightly furrowed brush, which is evenly attenuated toward apex; terminal joint shorter than second, somewhat thickened with scales in front, compressed, pointed. Maxillary palpi minute, deflected. Tongue long, spiraled, scaled in its entire length. Antennæ serrated and finely ciliated on the underside; basal joint with heavy but sparse (5–6) pecten. Thorax smooth. Forewings (fig. 1, *A*) elongate ovate, pointed, smooth; 12 veins, 7 and 8

stalked to costa, rest separate, 1b furcate at base.[1] Hindwings (fig. 1, *B*) somewhat broader than forewings, trapezoidal; costa deflected from the middle; apex pointed; termen sinuate; 8 veins; 8 connected with cell by an oblique bar; 6 and 7 closely approximate at base; 3 and 4 connate; 5 parallel with 4; frenulum simple in the males, triple in the females. Male genitalia (Pl. 8, *B*), with harpes and uncus well developed; tegumen evenly chitinized. Posterior tibiæ (Pl. 8, *A*) hairy above.

LARVA.—Head (text fig. 2 and Pl. 9) spherical, nearly circular in outline viewed from above, a little wider than long; greatest width a little behind the middle; incision of dorsal hind margin about one-fourth of the diameter of the head; distance between dorsal extremities of hind margin about one-half of the width of the head. Front triangular, reaching beyond the middle; adfrontal sutures somewhat undulating,

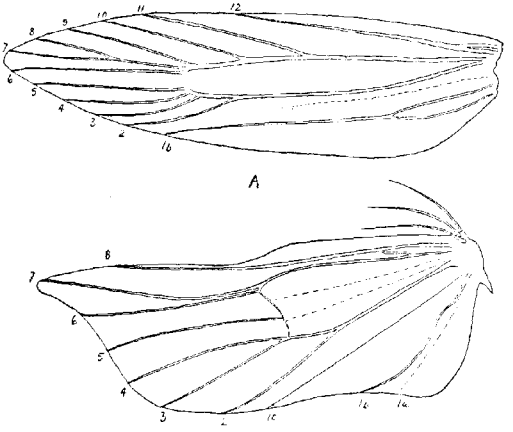


FIG. 1.—*Pectinophora gossypiella*: *A*, Venation of forewing; *B*, venation of hindwing.

reaching to the incision of hind margin; adfrontal ridges converging from near the middle, at the point of attachment of tentorial arms, to the longitudinal ridge, which is one-half as long as front. Projection of the dorsal margin over the ventral is one-half of the diameter of the head. Triangular plates of hypostoma distinctly separated by a slightly pigmented gula, nearly equilateral, but somewhat elongated and projecting slightly beyond the ventral margin of epicranium.

Ocelli six; i, ii, v, and vi forming a parallelogram; iii and iv on a line between ii and v; v smaller than the rest.[2] Epistoma with the usual two pairs of setæ (E_1, E_2) well developed.

[1] The European (*Gelechia*) *Pectinophora malvella* Zeller exhibits an amount of variation of the venation in the forewing which is very unusual in this group of insects. Veins 2 and 3 in this species are sometimes coincident or partly coincident at base or at tip; the variations sometimes differing in the two wings of the same insect. No such variation has been ascertained in *P. gossypiella*, where the venation seems constant, as given above.

[2] This numbering of the eyes differs from that of Fracker in that his numbers 5 and 6 are reversed, so as to make them continuous with the rest. (Fracker, S. B. The Classification of Lepidopterous Larvæ . . . 169 p., 10 pl. Urbana, Ill., 1915. Bibliography, p. 145–146. Illinois Biological Monographs, v. 2, no. 1.)

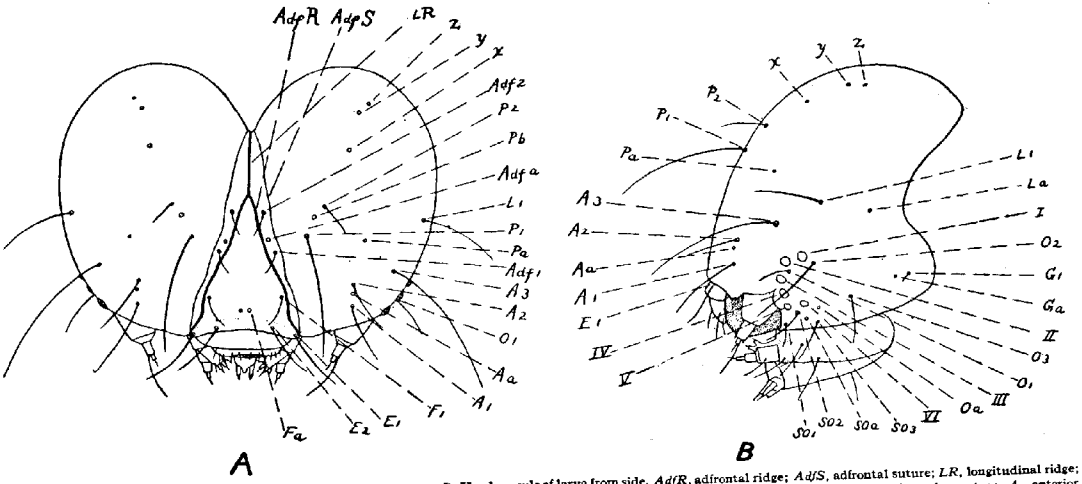


FIG. 2.—*Pectinophora gossypiella: A*, Head capsule of larva from front. *B*, Head capsule of larva from side. *AdfR*, adfrontal ridge; *AdfS*, adfrontal suture; *LR*, longitudinal ridge; E_1, epistomal seta, 1; E_2, epistomal seta, 2; F_a, frontal puncture; F_1, frontal seta; Adf_1, adfrontal seta 1; Adf_2, adfrontal seta 2; *Adfa*, adfrontal puncture; A_1, anterior seta 1; A_2, anterior seta 2; A_3, anterior seta 3; *Aa*, anterior puncture; P_1, posterior seta 1; P_2, posterior seta 2; *Pa*, posterior puncture a; *Pb*, posterior puncture b; *x*, *y*, and *z*, ultraposterior punctures; L_1, lateral seta; *La*, lateral puncture; *I*, ocellus i; *II*, ocellus ii; *III*, ocellus iii; *IV*, ocellus iv; *V*, ocellus v; *VI*, ocellus vi; O_1, ocellar seta 1; O_2, ocellar seta 2; O_3 ocellar seta 3; *Oa*, ocellar puncture; SO_1, subocellar seta 1; SO_2, subocellar seta 2; SO_3, subocellar seta 3; *SOa*, subocellar puncture; G_1, genal seta; *Ga*, genal puncture.

Frontal punctures (Fa) close together, anterior to frontal setæ (F_1); distance between punctures less than distance between puncture (Fa) and setæ (F_1); frontal setæ (F_1) and adfrontal setæ (Adf_1 and Adf_2) nearly equidistant; second adfrontal seta (Adf_2) approximate to but before beginning of longitudinal ridge (LR); adfrontal puncture (Adfa) midway between adfrontal setæ.

Epicranium with normal number of primary setæ, 13, and punctures, 7, and with three small ultraposterior punctures,[1] (x, y, and z).[2]

Anterior setæ[3] (A_1, A_2, A_3) in a slightly obtuse angle; A_1 and A_2 closer together than A_2 and A_3; anterior puncture (Aa) between A_1 and A_2. Posterior setæ[4] (P_1, P_2) and posterior punctures (Pa, Pb) near the middle of the head; P_1 on the level with adfrontal puncture[5]; P_2 posterior to Adf_2. Pa equidistant from P_1, A_3 and the lateral seta (L_1), remote from anterior group, nearly on the level with P_1; lateral seta (L_1) remote from A_3, nearly on the level of Pb; lateral puncture (La) posteroventral to the seta, remote. Of the ocellar setæ (O_1, O_2, O_3),[6] O_1 is equidistant from and lateral to ocelli ii and iii, O_2 is closely approximate and posteroventral to ocellus i; O_3 is directly ventral and remote from O_2, on a line with ocelli v and vi; ocellar puncture (Oa) between O_3 and ocellus vi, approximate to latter. Subocellar setæ (So_1, So_2, So_3) triangularly placed, nearly equidistant; subocellar puncture (Soa) between and equidistant from So_2 and So_3. Genal seta (G_1) and puncture (Ga) both present; puncture anterior to seta.

Labrum (Pl. 10, *I*, *J*) with median incision rather deep and evenly rounded. The three lateral setæ (La_1, La_2, La_3) close to edge, La_1 and La_2 closely approximate, La_3 remote; median setæ (M_1, M_2, M_3) in the usual Micro arrangement with M_2 lateral and slightly posterior to M_1; M_3 close to anterior margin on a line with La_3; M_1 and M_2 on a line respectively with La_2 and La_1.

Epipharyngeal shield (ES) merely a slight chitinization of the edge of the median incision; epipharyngeal setæ narrow plates, triangularly grouped near anterior margin. Epipharyngeal rods not discernible in the labrum proper, only represented by their posterior projections, which are rather well developed.

Mandibles (Pl. 10, *D*–*G*) strong, as broad as long, with four stout, rather short teeth; the three lower ones pointed; the upper blunt; a fifth lower tooth is slightly indicated on the underside; one long and one shorter seta on upper side near lower edge.

Labium and maxillæ normal (Pl. 9, *C*).

Antennæ (Pl. 10, *H*) four-jointed, with second joint considerably longer than joint 3, longer than broad; the longer seta longer than the entire antenna; papillæ minute, much shorter than third joint.

Three pairs of normal thoracic feet; four pairs of abdominal prolegs with crotches of uniform size in an incomplete circle, opening outwardly (Pl. 10, *K*); anal prolegs with a transverse row of uniordinal hooks.

The arrangement of the body setæ is normal, as shown in Plate 11, *A*, *B*. It differs from that of Gelechia in having the three setæ on prespiracular plate of prothorax nearly equidistant, while in Gelechia the posterior seta is farther separated from the two others than they are from each other, and in having the three setæ vii of the proleg-bearing abdominal segments arranged in a triangle, not in a line as in Gelechia.

[1] The nomenclature of the head setæ has been adopted from Heinrich (33) with certain minor modifications, noted in the following footnotes and concurred in by Mr. Heinrich.

[2] So-called "secondary punctures" of Heinrich, sometimes bearing minute setæ.

[3] Anterodorsal setæ of Heinrich.

[4] Posterodorsal setæ of Heinrich.

[5] The term "on the level with" is used in these descriptions as the head setæ are seen in frontal projection (fig. 2, *A*); anything above a level is termed "posterior" and anything below is termed "anterior."

[6] Heinrich's numbering reversed.

The genus differs further from Gelechia in the possession of an antennal pecten in the moth, and in the arrangement of the setæ of the larval head; Aa is anterior to A_2, not posterior to it as in Gelechia; P_1 and P_2 are posterior respectively to Adf_1 and Adf_2, which in Gelechia are nearly opposite to these, and L_1 is posterior to P_1, not on the level with it as in Gelechia.

The most striking larval difference is in the crotches of the abdominal prolegs, which are uniordinal and arranged in an incomplete circle, broken outwardly (Pl. 10, *K*). In Gelechia they are biordinal and in a complete circle.

PUPA.—The pupa of *Pectinophora gossypiella* is pubescent, without any long setæ except on last joint, and thus is easily distinguished from the smooth, seta-bearing pupa of Gelechia; cremaster present.

SPECIFIC DESCRIPTION

MOTH (Pl. 7, *A*.)—Labial palpi reddish brown; second joint with two diffused black bars exteriorly; terminal joint with two well-defined, broad, black annulations, one at base, the other at apical fourth. Antennæ brown with narrow black annulations; basal joint with long black pecten. Face and head light reddish brown with some pale iridescent scales. Thorax reddish brown with a sprinkling of black around the collar; patagia somewhat lighter brown, unmottled. Forewings darker brown with a series of small, ill-defined, black spots along the costal edge from base to apical fourth, where there is a larger dash of light ocherous brown; dorsal edge and apical part of wing suffused with darker, blackish brown; the middle of the wing is irregularly sprinkled with blackish scales and contains on the cell an ill-defined, round, blackish spot, sometimes divided into an upper and lower spot; there is also a smaller spot on the base of the cell; the pattern of the wing is rather vague and there is considerable variation in different specimens; in many there is an ill-defined blackish fascia at apical fourth just before the light costal dash, but in other specimens this fascia is not present and the round dorsal spot is dissolved into several smaller spots. Cilia light ocherous brown, streaked with blackish. Hindwings dark fuscous, somewhat iridescent, lightest towards base; cilia ocherous, terminal and apical parts suffused with dark fuscous; vein 1c with long, ocherous fuscous hairs on the upper side. Abdomen flattened and ocherous above, dark brown laterally with underside suffused with black and with ocherous scaling at the joints. Legs (Pl. 8, *A*) blackish fuscous with narrow ocherous annulations at the joints. The abdomen is very similarly shaped in the male and in the female and it is exceedingly difficult to distinguish the sexes, even in living moths, without dissection or by examination of the frenulum. The male genitalia (Pl. 8, *B*) are remarkably small in proportion to the size of the species: harpes narrow at base, broadening towards tip; tip strongly haired; a cluster of long, heavy, straight spines from inner side, well within the tip; sacculus armed on its edge with a row of stout spines; uncus moderately long, broad at base, tapering to a point, laterally heavily haired; ædœagus short, stout, with a terminal hook. In the female the ovipositor is weakly chitinized, covered with stiff hairs; genital plate heart shaped; bursa copulatrix with two opposite, strongly chitinized, hornlike, serrated invaginations (Pl. 8, *C*).

Alar expanse 15 to 20 mm.

FULL-GROWN LARVA.—The full-grown larva (Pl. 11, *A*) is 11 to 13 mm. long, cylindrical, white, with dorsal side strongly suffused with pink. Head reddish brown, with blackish brown mandibles and the other trophi yellowish. Thoracic shield rather small, divided in the middle, dark brown. Anal plate small, dark brown. Tubercles small, but distinct, yellowish brown, surrounded by deeper pink than the prevalent suffusion and bearing rather short, dark-brown setæ. Crotches of abdominal feet 15 to 17.

PUPA.—The pupa (Pl. 12, *A-D*) is 8 to 10 mm. long, rather plump, reddish brown; posterior end pointed and terminating in a short, stout, upwardly turned hooklike cremaster; entire surface finely pubescent; no long setæ, spines or hooks, except on last joint; fronto-clypeal suture distinct and curved sharply upward; clypeus, labrum, pupal eyes and mandibles distinctly indicated; antennæ diverging at their extreme tip and not reaching to the tips of the wings; metathoracic legs reaching slightly beyond the wings to fifth abdominal segment. Spiracles small, normal. Anal opening large, slitlike, surrounded by strong hooked setæ, 5 or 6 on each side; cremaster surrounded with 6 to 8 similar, strong, hooked setæ. Genital opening slitlike, single in both sexes. When mature, the pupa becomes much darker (Pl. 12, *C*); the imago's eyes can be seen prominently under the gena of the pupal skin, and the segmentation of the adult antennæ and legs becomes discernible.[1]

EGG.—Elongate oval, flattened; about 1 mm. long and 0.5 mm. broad; the shell is pearly white, with a finely wrinkled surface.[2] When newly laid, the egg has a slightly greenish tint. At maturity it turns reddish.

SEASONAL HISTORY AND NUMBER OF GENERATIONS[3]

The small eggs are difficult to detect without the aid of a lens. They are laid singly or in small groups on any part of the green cotton boll or its calyx or even in the flower, but are by far most commonly found near the apex of the green boll in the slight longitudinal depressions which indicate its divisions (fig. 3, *a*). From 1 to 4 eggs are commonly seen, and sometimes as many as 20 may be found on a single boll, probably laid by several females. The number of eggs laid by a single female is difficult to ascertain in nature, but dissections prove that each female is capable of laying more than 100 eggs. The egg hatches in from 4 to 12 days after it is laid.

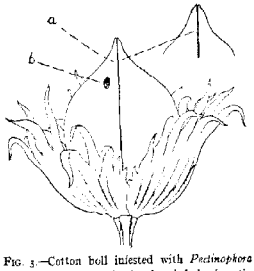


FIG. 3.—Cotton boll infested with *Pectinophora gossypiella*. *a*, Eggs *in situ*; *b*, exit hole of moth. (Original.)

The larva when first hatched is very small, glassy white, with light-brown head and thoracic shield. It tunnels into the boll under the egg-shell or near by and feeds in the beginning on the soft inner walls or in the equally soft partitions separating the divisions of the boll. The larva is easily overlooked at this stage when the boll is opened and

[1] The terminology of the pupa has been adopted from Miss Edna Mosher's valuable paper: (Mosher, Edna. A classification of the Lepidoptera based on Characters of the pupa. *In* Bul. Ill. State Lab. Nat. Hist., v. 12, art. 2, p. 17–159, pl. 19–27. 1916.)

[2] The egg has been described by Fullaway (16, p. 18, fig. 10) as having "a peculiar sculpturing of the surface, which renders them unmistakable when observed with a hand lens," and his figure shows a regular cross-line effect, but there is no such true sculpture of the egg surface. When laid, the egg is soft and smooth and the surface merely becomes irregularly wrinkled shortly after it is laid.

[3] The biological observations on which this paper is based were made by the writer in 1915 in Honolulu, T. H.; but they coincide with the results of other students of the insect in other parts of the world, and the data will undoubtedly hold true, with slight modifications, in the United States, if the pest becomes established here.

examined; but the minute entrance hole with a small amount of pellets of reddish frass and the empty shell of the egg are sure indications of infestation, and dissection of the boll will reveal the small larva mining within the wall.

Infested bolls normally become more or less recognizable by discoloration of the shell, which soon assumes a reddish or black color over the infestation; but as such discoloration may occur in uninfested bolls from other injury and does not always follow infestation of the pink bollworm, no conclusive discrimination between infested and uninfested bolls can be made without the discovery of the eggshell and the entrance hole.

There is considerable individual variation in the further course of the attack, partly depending upon the location of the egg and the condition of the boll and partly upon the direction the larva may happen to choose. Most commonly the larva bores in near the apex of the boll and tunnels down through the walls to the base before it attacks one of the lowest seeds. This it eats partially and then proceeds to the next seed above, ending as a full-grown larva in one of the seeds nearest the tip of the boll. Sometimes, however, the opposite movement takes place. A larva generally confines itself to a single section of the boll, but an adjoining section is often invaded, and sometimes all sections will be more or less attacked by a single larva.

If a boll for any reason becomes unsuitable, the larva will readily leave it and migrate to another, into which it eats its way through the shell, making a large, conspicuous, frass-surrounded hole.

The larva eats the seeds and tunnels and soils the lint, causing the arrest of the growth and the rotting or premature and imperfect opening of the boll. Not only the seeds and the lint actually attacked are lost, but the uninfested parts of the boll are retarded in growth and greatly depreciated in value by the attack of even a single larva. When, as is often the case, two, three, or more larvæ infest a single boll, the value of the seeds and lint is entirely destroyed.

The larva is exclusively an inside feeder within the boll and does not attack the leaves or shoots of cotton. Sometimes the young larvæ may be found in the ovary of the flower, devouring the tender ovules and preventing the formation of the lint. Such larvæ rarely attain their full growth in the flower, but migrate to a boll for their later support. Much more commonly, however, it is the larger, well-formed boll, which is attacked.

There are four larval instars. The younger larvæ are nearly pure white, with a brown head, thoracic shield, and tubercles. It is only in its last stage that the larva assumes the strong pink suffusion which has caused its popular name "pink bollworm."[1]

[1] It should be noted that the larvæ of many other Microlepidoptera assume a similar red or pinkish coloration at maturity and that the larva of *Pyroderces rileyi*, described in the latter part of this paper, which also occurs in cotton bolls, has a decided reddish color throughout its life.

The larval stage from the hatching of the egg to the spinning of the cocoon occupies from 20 to 30 days during the summer. During the colder months, or under abnormal, dry conditions, the larval period may be much prolonged. The species overwinters as larva within the seeds.

The larva normally makes its cocoon and pupates within the boll, partly within the last seed attacked. Before finishing the cocoon the larva gnaws a round hole through the outer wall of the boll to insure free exit for the issuing moth (fig. 3, *b*). It has an evident preference for a firm cover for its cocoon and a firm support for the imago to issue from. The cocoon is always spun next to the shell of the boll, and the exit hole is invariably gnawed through the shell, which at that time is often woody and hard, although an easier and more abundant exit surface could be found in all other directions through the loose lint of the boll, which by this time has opened.

The cocoon consists of a single thin, but rather tough, layer of dirty-brown silk. If disturbed at the time of maturity the larva may leave the boll, fall to the ground, and spin its cocoon an inch or more down in the soil or in any convenient shelter under a stone or among brush and leaves and will successfully finish its transformation. Under normal conditions in the field, however, the pupation nearly always takes place within the boll.

The pupal period lasts from 10 to 20 days. The empty pupal shell remains within the cocoon when the moth issues.

The imago is a small, inconspicuous, sluggish moth, rarely seen in nature, because it hides away during the day, mostly on the ground under stones or in brush, sometimes actually burrowing into the surface of the soil. The time of flight is from 6.30 to 8 p. m.; but, though the moths have ample wings for a strong, sustaining flight, they fly only to the nearest cotton bolls for copulation and egg laying, which under normal conditions takes place soon after issue.

The moths die shortly after oviposition. Under most favorable conditions, in a cool place supplied with water, some moths were kept alive for 32 days, but the majority died even under these conditions in from 14 to 20 days.

The entire life from the laying of the egg to the next egg laying may be accomplished under favorable conditions in 35 days, but 40 to 50 days is the more common period even in midsummer, and in the colder months the life cycle may extend over three or four months. Thus, four or five or even six overlapping generations may be produced in a year.

The winter is passed in the larva stage in the seed.

The writer's observations in Honolulu in 1915 began on May 18. At that date the insect was found in all stages; eggs, larvæ, and pupæ were obtained in the field, and one moth issued from one of the collected pupæ the following morning. About 50 per cent of the green bolls were infested at this date.

Throughout the following five months eggs, larvæ, and pupæ were collected and moths issued in the rearing jars every day. By September the percentage of infested bolls was 90 to 99 in the different fields under observation

HABITS OF THE IMAGO

The imago of the pink bollworm is an inconspicuously colored moth and is very rarely observed in nature. The inconspicuousness, however, is due as much to the retired habits of the moth as to its color and is paralleled in many other Microlepidoptera. Such a common insect, for example, as the codling moth (*Carpocapsa*) *Laspeyresia pomonella*, is seldom or never observed in nature.

It is very perplexing to walk through a heavily infested cotton field and not to be able to discover a single moth, although one knows that thousands of them have issued that morning and other thousands every day for a week and that all these thousands must be somewhere near you.

The moths find their resting places during the day near or on the ground, in rubbish around the roots of the plants, or under stones. They often partially burrow into the surface of the ground for shade and concealment. Only occasionally is a specimen found on the cotton, hidden away at the base of the boll, under the large calyx.

As an experiment, several dozen moths which had issued in the rearing cages were repeatedly liberated in the middle of a cotton field by shaking them out of a jar onto the ground. Within a minute none were in plain sight. All had effectively hidden away, mostly on the uneven surface of the ground.

The same secretive habit prevails under artificial conditions indoors. Hundreds of moths were reared weekly and liberated in a small rearing house, yet rarely were any in sight after a few hours. Two hundred moths were liberated daily in a living room on seven successive days, but only by search were any to be found during the daytime.

REACTION TO LIGHT

Like most of its relatives, the cotton moth is negatively heliotropic and invariably seeks protection from direct sunlight and even from diffused daylight. Its time of activity is, as before stated, at dusk, from 6.30 to 8 p. m. Of a hundred or more newly issued moths liberated daily in the rearing house, a large percentage would, on the opening of the rearing jars, fly to the screened north wall of the house in an effort to escape, but shortly afterward they would be found to have left the light-exposed screens and to have crawled or flown to darker parts of the house, especially to the corners near the floor.

Nor is artificial light an attraction to the moths of this species, as it is to a large number of other Microlepidoptera. Strong kerosene and acety-

lene lamps, placed in a most effective manner, with white sheets as backgrounds, on a porch and in the windows of a cottage surrounded, within 20 feet, by heavily infested cotton fields, failed to attract a single individual of *P. gossypiella* during many evenings and nights, though efforts were made to disturb and dislodge them in the fields by beating and shaking the cotton bushes.

The trapping of these moths by light has been recorded and recommended and special lantern traps, which were believed to be effective, have even been constructed and figured (5, 8, 18, 19, 27, 30); but this method of combating the pest is certainly futile. The idea that these moths were attracted to light is based on very unsatisfactory evidence and is probably due to misidentification of the material collected in the traps.

The cotton fields abound in Microlepidoptera. In Honolulu the leaf-folder *Tortrix postvittana* Walker and the scavengers *Cryptoblabes aliena* and *Opogona aurisquamosa* Butler are common in the cotton fields and are of about the same size as *P. gossypiella*. These species are attracted to light, and it has probably been specimens of these and other species which were captured in the traps.

In order to study the behavior of the moth indoors and to verify, if possible, the records of their attraction to light under such conditions, a large number (200 a day for a week) of freshly emerged moths were liberated in a large living room in Honolulu. During the day none of these moths were noticeable, except when searched for in the dark corners or accidently disturbed by the movement of a curtain or a towel. At 6.30 p. m. all these moths would come to the windows, seeking their way outdoors, and would remain motionless on the screens or curtains until daylight next morning. Then they would fly back to the dark corners of the room. If in the evening an electric lamp was lighted near the window, some of the many moths in the immediate vicinity would be disturbed and for a short time would be blinded by the strong light and would even settle on or near the lamp; but as many or more would fly away. Only very rarely would a cotton moth come within the glare of an acetylene hand lamp carried at night in the cotton field; but, if it did, it would invariably endeavor to fly away from the light.

From very many varied and repeated observations under different conditions it may be definitely stated, notwithstanding the many other statements to the contrary, that *Pectinophora gossypiella* is not attracted to light, but is, on the contrary, shy of all light, natural and artificial.[1]

It has been suggested that a darkened space might be a barrier which the moths would not fly into or through. If such was the case, it might have a practical bearing in the prevention of the escape of the moths from cotton mills; but this is not true. The tendency of the moths, on the contrary, is to fly into such a dark space.

[1] Vosseler (7, p. 407) and Stuhlmann (11, p. 218) have reached the same result.

A small cottage of five rooms (fig. 4) on one floor was utilized in testing the behavior of the moths in relation to light and darkness. All of the rooms opened out on a narrow, central passageway (*E*), 15 feet long, which could be made the darkest part of the house by closing up the main entrance. Several hundred moths were liberated on different days in the rooms. A large percentage (nearly half) could always be found after a few hours in the dark passageway. At 6.30 p. m., if the front entrance was closed, these moths would leave the passageway and come to the screened windows of the rooms, seeking exit to the outdoors. Two hundred to three hundred moths, liberated one afternoon in a small darkened room (*B*) at the end of the dark passageway at 6.30 p. m., flew through the length of this 15-foot passageway out into the open air; nor were they hindered in doing this when the porch outside was lighted by a strong light. It is noteworthy that not a single moth was attracted to the light on the porch, but that all flew right out through the light space to the cotton fields beyond.

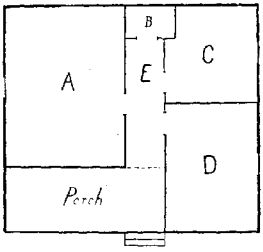


FIG. 4.—Plan of the house used for observations on the behavior of the moths of the pink bollworm in relation to light. (Original.)

It is apparent, therefore, that neither a darkened space nor a sheet of light is an effective barrier to the flight of these moths.

LONGEVITY OF THE LARVA AND BEHAVIOR UNDER ARTIFICIAL CONDITIONS

As already stated, the larval life of *P. gossypiella* is accomplished under normal summer conditions in from 20 to 30 days, but if the young larva is confined to dry and hard cotton seeds, either artificially or, as may happen, in prematurely ripening bolls in the field, it will live much longer. Half-grown larvæ kept in dry cotton seeds in a cool place from June to September eventually reached maturity, pupated, and issued successfully as moths. The life of the hibernating larva is normally longer, from 3 to 5 months; but these also may live for a much longer period under dry conditions unfavorable for the issue of the imago. Heavily infested, unginned seeds were baled under strong pressure into small trial bales (24 by 12 by 18 inches) in September, 1915, and placed in dry rearing boxes indoors in Honolulu. One of these bales was examined every month afterwards, and numbers of live healthy larvæ were found on each examination up to March, 1917. It was thus actually proved that the suspension of larval life may extend over 18 months; and there is no doubt, from observations of other seed-feeding lepidopterous larvæ, that the

pink bollworm may keep alive and be capable of eventual maturity even longer than this.[1] This ability of the larva to sustain life within the seed for a prolonged period has an important bearing on the spread of the species, as the larvæ may be transported any distance with the seed and may transform successfully and produce imagoes capable of reproduction whenever conditions become favorable.

This possible suspension of the larval life renders of uncertain value any storing of the seed as a safeguard against infestation from such seed.[2]

The instinct of the larva to provide a safe exit to the outer world for the moth in the field by gnawing a hole through the husk of the boll, preliminary to the spinning of its cocoon, governs the larva also under artificial conditions. If an infested boll is wrapped in tissue paper or in cloth, the larva will bite its exit hole through these additional layers, spinning its cocoon within the hole. Also, if a mature larva is confined in a small pill box or in a capsule, it will tunnel a hole through to the outer world and then, conditions being otherwise suitable, will spin its cocoon within the hole. When green infested bolls are inclosed in a sack, such larvæ as are ready to pupate will leave the bolls and eat their way out through the sack to find suitable places outside for their cocoons. Even a heavy canvas or khaki bag is no barrier. If the larva matures within a bale of dry cotton and is sufficiently near the surface of the bale to be able to work through the packed cotton, it will do so and cut its way through the covering of the bale. Such a larva will not normally make its cocoon within the hole in the sack or in the covering of the bale, but will seek a suitable place outside because of its instinct to find a firm support for the issuing moth.

This tendency in the larva to seek free access to the outer world for the issuing imago has an important bearing on the precautions necessary to insure against the introduction of the pest into the United States with imported baled cotton. It renders absolutely valueless as a preventive any burlap covering of the bales. Such covering will in no degree lessen the possibility of importation, as any larva which may be in the bale and which is able to come to the surface can easily cut through the covering, and will invariably do so. Such larvæ as are within seeds deeper in the bale will remain quiescent until the bale is opened and the pressure relieved, when they will issue quickly from the seeds and complete their transformation.

[1] Gough (36) found larvæ hibernating over two years in Egypt.

[2] This applies particularly to seeds stored under usual conditions in a temperate climate—that is, within the bolls and in cool dark rooms unsuitable for the issuing of the imago. In the warm climate of Honolulu, however, it was found that loosely stored cotton seeds in open bins would be entirely free of larvæ in the course of a few months, contrary to the results obtained with baled cotton.

Vosseler (7, p. 407) also records an experiment with infested seeds placed on a sheet in the sun in which all the larvæ left the seeds in a few hours.

MANNER OF DISPERSION

While *P. gossypiella* has ample wing power for an insect of its size and is capable of strong, darting flight, it is not mainly by flight that the distribution of the species to new fields is effected. The moths are rather too sluggish for sustained flight, and it is only fields near by or actually adjoining that are infested in this way.

A group of a dozen cotton plants growing only some 4,000 to 5,000 feet from the heavily infested cotton field under special observation was found well infested in early June. All the bolls, squares, and flowers were removed from these 12 plants, and the new crop of bolls, maturing in September and October, remained entirely free from infestation, although thousands of moths were liberated during the summer from the breeding house, situated some 4,000 to 5,000 feet away from them and in the opposite direction from the infested field.

Single cotton trees, grown as ornaments in gardens in different parts of Honolulu, were found entirely free from the pest throughout the summer, though others a few blocks away were heavily infested.

Nor does the wind ordinarily play any considerable rôle in the dispersion of the pest. The moths normally remain quiet in any strong breeze and, if accidently dislodged by the wind, drop to the ground as soon as possible. Specimens were repeatedly shaken out of rearing jars in strong winds. Such specimens would be carried with the wind for a short distance, but would invariably soon settle down on the ground. The dispersion of the species by the wind, however, can not be disregarded. Under favorable conditions it is possible for both the moths and the larvæ which happen to be in loose detached cotton lint to be carried by a strong wind for a considerable distance from field to field.

By far the most important agent in the distribution of the pest is man. Owing to the possible suspension of the larval life for a prolonged period, hibernating larvæ may be transported to any distance within the seed of cotton and in due time produce adults. It is in this manner that the species has become distributed with cotton importations over such large areas and from continent to continent.

FOOD PLANTS

The writer, from his observations in the Hawaiian Islands, is convinced that the pink bollworm is confined to the genus Gossypium. Statements that it feeds also in various malvaceous and other plants are probably due to wrong determinations of the insect.

Maxwell-Lefroy states (9) that the species feeds in species of Hibiscus in India; Dudgeon (28) records it from pomegranate in Egypt; Fullaway (16) has reported it from milo (*Thespesia populnea*) in Hawaii.

This last record, however, was based on the rearing of a single specimen from a fallen fruit of milo on the ground of the Agricultural Experiment

Station in Honolulu, and Dr. Fullaway agrees that this might well have been from a stray mature larva which had accidently crawled into a cracked milo fruit for pupation. In order to test the record, the writer collected fruits in all stages from the milo trees on the Experiment Station grounds as well as elsewhere during the summer of 1915, examining many hundred fruits and keeping as many more in cages. Not a single pink bollworm was found in or reared from these fruits, although from 50 to 500 reared moths were liberated every week during the summer in and under the trees in an effort to have them oviposit there.

Similar observations were made with the fruits of other malvaceous plants, particularly the hau (*Pariti tiliaceum*) and the wild hibiscus (*Hibiscus arnottianus*). Large lots of the fruits were collected and examined for larvæ, and other lots were placed in rearing jars in an effort to substantiate the statements that they are food plants of the pink bollworm, but not a single specimen was either reared from or found in these fruits. The fruits of hibiscus in Hawaii harbor a microlepidopterous larva about the same size as the pink bollworm, and this is presumably the foundation for the statement in Hawaii; but these larvæ belong to a different insect, (*Crocidocema*) *Eucosma marcidellus* Walsingham.

The pink bollworm, on the other hand, was most unexpectedly found in and reared from *Gossypium tomentosum*, the small dry fruits of which seem quite unsuitable for the species. This species of Gossypium is indigenous to the Hawaiian Islands.

Among the several varieties of cultivated cotton, the pink bollworm seems to have no choice. The perennial Caravonica cotton is by far the most commonly cultivated variety in the Hawaiian Islands; but the bollworm attacked just as readily plots of Chinese, Sea Island, and American Upland cotton growing in the Agricultural Experiment Station grounds in Honolulu.

PARASITES

The larva of *P. gossypiella* is so effectively protected within the green boll that no parasite at present found in the Hawaiian Islands can reach it as long as the shell is intact. It is only after the boll has opened or after the larva has bored its exit hole through the husk that parasites can gain access to it.

The following five species of hymenopterous parasites were reared in Honolulu during the summer of 1915 from *P. gossypiella*, but none of these is an effective check on the pest, and, all combined, they do not infest more than a small percentage: *Chalcis obscurata* Walker; *Stomatoceras pertorvus* Girault; *Pimpla* (*Hoplectes*) *hawaiensis* Cameron; *Chelonus blackburnii* Cameron; *Paristerola emigrata*[1] Rohwer.

[1] A closely allied species, *Paristerola nigrifemur* Ashmead, is parasitic on the pink bollworm in Brazil. Maxwell-Lefroy (17) records *Apanteles depressariæ* as parasitic on *P. gossypiella* in India, and Willcocks records (33) *Pimpla* sp. and (34) a braconid parasite from Egypt.

The first four of these species are parasites of the pupa. These species have other hosts besides *P. gossypiella*, and they play practically no rôle in the reduction of the species, since altogether they do not kill more than a fraction of 1 per cent.

The last-named bethylid, *Parisierola emigrata*, is an external parasite of the full-grown larva. The female works her way either through the exit hole of the cotton worm or through the lint of the opened boll into the cell in which the larva is preparing to pupate. She jumps upon the larva and paralyzes it by inserting her sting into the nervous system of the caterpillar, usually just behind the last thoracic legs. When the parasite has assured itself by biting and pulling the body of the larva that the paralyzation is effective, it deposits its eggs. These are rather large, glassy white, and normally placed one on a segment, in two rows on the underside of the caterpillar. Four to six eggs are most commonly laid on one host larva, but as many as seventeen were laid in captivity, and repeatedly eight to twelve could be found in the field. These eggs hatch within 24 hours, and the parasitic larvæ grow quickly and form a rosette on the shriveling body of the host. They become full grown in two or three days and then spin their cocoons near the host larva. The spinning of the cocoon occupies nearly two days, and before it is completed the larva voids a large fluid excrement through an opening left in the as-yet-unfinished cocoon. These excrements harden into a characteristic bifurcated black substance, which often serves to glue the cocoon to the supporting surface.

When there have been many parasites (8 to 17) on a single caterpillar, their cocoons are flimsy and white; but, when only four to six parasites have found nourishment in a single larva, they average larger in size and their cocoons are more substantial and are brownish in color.

The pupa of the parasite is at first white, with coral-red eyes, but it turns blackish within a few days. The parasite issues in from 10 to 15 days after the egg is laid.

It may be mentioned that a very large percentage of these parasites are females, about 30 to 1 male, and that parthenogenesis was repeatedly observed—seemed in fact to be the normal condition. Four generations consisting exclusively of females were produced in one experiment from a single unfertilized female.[1]

This bethylid was first recorded from Hawaii in 1912 and had been introduced only shortly before that time, probably from the United States. It is found rather commonly in all cotton fields on Oahu and in the Kona district, Hawaii, and it is the only parasite of *P. gossypiella* of any importance at present in the Hawaiian Islands. It is by no means an effective check, however, and destroys only 1 to 4 per cent of the larvæ.

[1] The life history of this species was published by the writer (40) and notes on the species by Fullaway (29).

More effective parasites of *P. gossypiella* might be expected to be found in the original home of the species, Africa, but no record of such has been made.

It is also possible that the congeneric species, *P. malvella*, found in Europe and Africa, or any other lepidopterous species with similar biology, may be preyed upon by parasites which could become of value against the pink bollworm.

An egg parasite would be by far the most promising for effective results, first, because the egg is the only stage of the species which is easily reached by a parasite, and, secondly, because the insect is thus destroyed before it has had a chance to do damage. As soon as the larva has bored into the boll, it is reasonably safe from parasites, and, even if killed, has already done serious damage to the boll. *Trichogramma minuta* Riley, which is parasitic on the eggs of the codling moth in this country, or any other species parasitic on singly laid, exposed eggs of Microlepidoptera, would be worthy of trial.

OTHER NATURAL ENEMIES

There are no predacious insects playing any rôle in the reduction of *P. gossypiella* in the Hawaiian Islands, and it is doubtful whether any such insect could be of economic value. The larvæ within the bolls are quite safe from them; and the numbers of moths which, for example, a mantis could catch would be quite negligible.

Large numbers of the predacious mite *Pediculoides ventricosus* Newport were found in a few instances in cotton bolls in Honolulu, and they had invariably killed the *P. gossypiella* larvæ present. This mite has also been received from Brazil with the remains of larvæ of *P. gossypiella* which it had destroyed. It is also recorded as an enemy of the pink bollworm in Egypt (33), but it seems doubtful that it can ever be really effective in the field against *P. gossypiella*. If in exceptional cases it should become sufficiently numerous to be a check on the pink bollworm, its presence would probably be so obnoxious to the workers in the field as to counteract its value as a parasite. In stored cotton this predator might readily have some effect in killing off the hibernating larvæ, but the same results may be obtained in a quicker and surer way by fumigation, and it is not believed that *Pediculoides ventricosus* can be successfully employed in any organized fight against the cotton pest.

There are very few wild birds in the cotton fields of the Hawaiian Islands, and they play no rôle in keeping the pest in check; but domestic fowls are of some benefit. In one cotton plantation on the Island of Oahu a large number of chickens, ducks, and turkeys had free access to certain inclosed areas of cotton. These birds materially assisted in the reduction of the pest by eating a large number of the moths and such larvæ as accidentally fell to the ground.[1]

[1] Vosseler (5) records that chickens and ducks voraciously picked up *P. gossypiella* larvæ which made their escape from the bolls placed on a sheet in strong direct sunlight.

Opportunity was not afforded to test this means as thoroughly as would have been desirable, by having separate plots of cotton with poultry compared with sufficiently distant control plots without poultry; but even without such careful tests it was evident that considerable protection was afforded by the poultry. Plots to which the fowls had access were less infested than adjoining plots from which they were excluded.[1]

SYNONYMY OF PECTINOPHORA GOSSYPIELLA SAUNDERS

Depressaria gossypiella Saunders (1).
Gelechia gossypiella Meyrick (6).
Gelechia gossypiella Walsingham (13).
Gelechia gossypiella Durrant (26).

THE SCAVENGER BOLLWORM, AN INSECT MISTAKEN FOR THE PINK BOLLWORM

The caterpillars of a few other species of small moths may occasionally be found in cotton bolls in the United States and have repeatedly been mistaken for the pink bollworm, causing anxiety that this dreaded pest had become established in American cotton fields.

Among such species are (*Platynota*) *Sparganothis idaeusalis* Walker and *S. rostrana* Walker, which belong to the family Tortricidae. The larvæ of these species are normally leaf-rollers on cotton and some other plants, but, especially in the fall of the year, they may enter the opened bolls, which afford convenient places for the larvæ to hibernate and pupate. These species rarely, if ever, do any actual primary damage to the bolls.

Much more common in the open cotton bolls are the small reddish caterpillars of *Pyroderces rileyi*, which, on account of their color, are likely to suggest the pink bollworm to the casual observer in the field, and which on several occasions have aroused unnecessary fears, even among entomologists.

This species is very commonly associated with cotton wherever this plant is grown, in both North America and South America, the West Indies, and the Hawaiian Islands.[2]

These larvæ, however, never do any independent primary injury to sound bolls, but live as scavengers in the more or less decayed dry bolls injured by other insects. The species is not confined to cotton, but feeds on dried and decayed fruits of many other plants.[3]

Aside from the color of the larva, there is only superficial resemblance between it and the pink bollworm; and even the color is somewhat different—much deeper and more reddish. Full grown, it is much smaller than the pink bollworm and appears more hairy because of the proportionally longer setæ; the actual number of hairs is the same in both

[1] Numerous experiments for the control of this species by insecticides have been recorded in literature (14, 31, 35, 38).

[2] A closely allied species, *Pyroderces simplex* Wlsm., is found as a scavenger in cotton in Africa.

[3] The species has been reported by Chittenden (48) as doing primary injury to corn in the husk, probably having been attracted to the decaying silk.

larvæ. Under a lens it is at once distinguished from the pink bollworm by the five-toothed mandibles (fig. 7) and the crotches of the abdominal prolegs, which form a complete circle (Pl. 10, *C*), not broken outwardly as in *P. gossypiella* (Pl. 10, *K*).

The following technical descriptions of *Pyroderces rileyi* will enable definite differentiation in all stages from *Pectinophora gossypiella*.

GENERIC DESCRIPTION

MOTH.—Labial palpi very long, recurved, sickle-shaped, reaching beyond vertex; second joint slightly thickened by smoothly appressed scales; terminal joint longer than second, smooth, acute. Antennæ simple, basal joint with strong pecten. Face, head, and thorax smooth. Forewings (fig. 5, *A*) narrow elongate, apex produced and pointed; 12 veins; 1b furcate at base; 2 and 3 approximate and parallel; 7 and 8

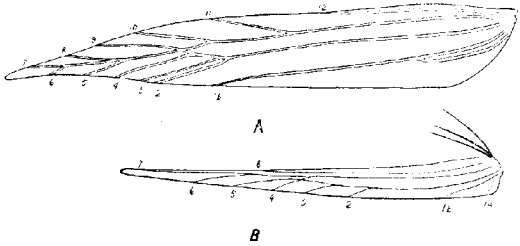


FIG. 5.—*Pyroderces rileyi*: *A*, Venation of forewing; *B*, venation of hindwing.

out of 6; 5 out of 6; 9 connate with or out of base of 6; 11 from beyond middle of cell. Hindwings (fig. 5, *A*) narrower than forewings, attenuated lanceolate, apex pointed; 8 veins; 6 and 7 stalked; 4 and 5 connate; 2, 3, and 4 widely separated. Posterior tibiæ (Pl. 8, *D*) roughly haired above. Male genitalia (Pl. 8, *E*) with harpes and uncus developed; tegumen evenly chitinized.

LARVA.—Head (fig. 6) somewhat flattened, nearly quadrate, viewed from above, somewhat broader than long, with margin rounded and deeply incised; greatest width well behind the middle; incision of dorsal hind margin about one-third of the diameter of the head; distance between dorsal extremities of hind margin about one half the width of the head. Front triangular, extending nearly to the incision of hind margin; adfrontal sutures straight, extending to incision of hind margin; longitudinal ridge short, not more than one-fourth as long as front. Projection of dorsal margin over ventral one-third of the diameter of the head. Triangular plates of hypostoma separated by a slightly pigmented gula, elongate. Ocelli six; i, ii, v, and vi forming a parallelogram; ii, iii, and iv in a straight line; iii and iv forward of the line between ii and v; iv and v smaller than the others. Epistoma with the usual two pairs of setæ (E_1, E_2) well developed. Frontal punctures (Fa) close together, almost on a line with frontal setæ (F_1). Distance between punctures slightly less than distance between puncture (Fa) and setæ (F_1); distance between frontal setæ (F_1) and first adfrontal setæ (Adf_1) greater than distance between adfrontal setæ Adf_1 and Adf_2; second adfrontal seta (Adf_2) closely approximate to beginning of longitudinal ridge (LR); adfrontal puncture approximate to Adf_2.

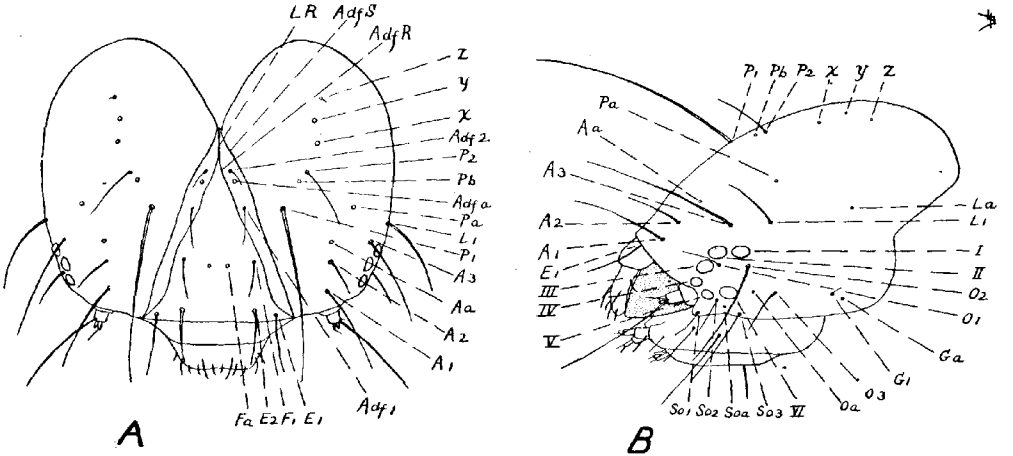


FIG. 6.—*Pyroderces rileyi: A*, Head capsule of larva from front. *B*, head capsule of larva from side. *AdfR*, adfrontal ridge; *AdfS*, adfrontal suture; *LR*, longitudinal ridge; E_1, epistomal seta 1; E_2, epistomal seta 2; *Fa*, frontal puncture; F_1, frontal seta; Adf_1, adfrontal seta 1; Adf_2, adfrontal seta 2; *Adfa*, adfrontal puncture; A_1, anterior seta 1; A_2, anterior seta 2; A_3, anterior seta 3; *Aa*, anterior puncture; P_1, posterior seta 1; P_2, posterior seta 2; *Pa*, posterior puncture a; *Pb*, posterior puncture b; *x*, *y*, and *z*, ultraposterior punctures; L_1, lateral seta; *La*, lateral puncture; *I*, ocellus i; *II*, ocellus ii; *III*, ocellus iii; *IV*, ocellus iv; *V*, ocellus v; *VI*, ocellus vi; O_1, ocellar seta 1; O_2, ocellar seta 2; O_3, ocellar seta 3; *Oa*, Ocellar puncture; SO_1, subocellar seta 1; SO_2, subocellar seta 2; SO_3, subocellar seta 3; *SOa*, subocellar puncture; G_1, genal seta; *Ga*, genal puncture.

Epicranium with normal number of primary setæ, 13, and punctures, 7, and with three small ultraposterior punctures (x, y, z).[1]

Anterior setæ (A_1, A_2, A_3) in an obtuse angle; A_1 and A_2 closer together than A_2 and A_3; anterior puncture Aa posterior to A_2 and on a line with A_1 and A_2; A_3 directly lateral to Aa. Posterior setæ (P_1, P_2) and posterior punctures (Pa, Pb) near the middle of the head; P_1 and P_2 on a level with Adf_1 and Adf_2, respectively; Pa on a line between L_1 and P_2, nearest L_1; Pb on a line between P_1 and P_2, approximate to P_2. Lateral setæ (L_1) closer to A_3 than A_3 is to A_2, anterior to P_1; lateral puncture (La) directly posterior to, and distant from the seta. Of the ocellar setæ (O_1, O_2, O_3) O_1 is equidistant from and lateral to ocelli ii and iii; O_2 closely approximate to and ventral to ocellus i; O_3 posteroventral to and remote from O_2, on a line with ocellus v and vi; ocellar puncture (Oa) between and equidistant from O_3 and ocellus vi. Subocellar setæ (So_1, So_2, So_3) triangularly placed, nearly equidistant; subocellar puncture (Soa) between and equidistant from So_2 and So_3. Genal seta (G_1) and puncture (Ga) both present; seta anterior to puncture.

Labrum (Pl. 10, *A*, *B*) with median incision acute, rather deep. The three lateral setæ (La_1, La_2, La_3) close to the edge; La_1 and La_2 approximate, La_3 remote. Median setæ (M_1, M_2, M_3) in the usual Micro arrangement with M_2 latera and slightly posterior to M_1; M_3 well back of anterior margin; M_1 and M_3 equidistant from M_2. M_1 on a line with La_2; M_2 slightly anterior of La_1.

Epipharyngeal shield (ES) small, arrow shaped; epipharyngeal setæ (ET) broad plates, triangularly placed; epipharyngeal rods not discernible within the labrum proper; posterior projections short.

Mandibles (fig. 7) longer than broad; 5 teeth, 4 lower teeth long and sharply pointed; upper fifth tooth rounded; one long and one shorter seta on upper side near lower edge.

Labium and maxillæ normal.

Antennæ four-jointed, with second joint more than half the length of the entire antennæ; papillæ long, pointed; long seta more than twice the length of the antenna.

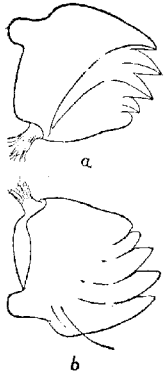


FIG. 7.—*Pyroderces rileyi*: Right mandible of larva. *a*, Underside; *b*, upper side. Greatly enlarged. (Original.)

Three pairs of normal thoracic feet; four pairs of abdominal prolegs with unevenly biordinal crotches, arranged in a complete circle; anal prolegs with a transverse line of biordinal crotches.

Setal arrangement of body normal, as shown in figures *C* and *D*, Plate 11.

PUPA.—Pupa smooth, with setæ on vertex, first thoracic, and on all but the first abdominal segments. No cremaster.

SPECIFIC DESCRIPTION

MOTH (Pl. 7, *B*).—Labial palpi light reddish brown; second joint with two ill-defined darker brown annulations; terminal joint with three blackish annulations. Head light chestnut-brown; lower face yellowish iridescent. Antennæ whitish with sharply defined, narrow, blackish brown annulations. Forewings chestnut brown with whitish straw-colored streaks, edged by irregular black scales; an oblique whitish fascia on basal third edged on the inner side with black; an ill-defined group of black scales in the middle of the wing, edged with white; a subcostal longitudinal white streak at apical third, terminating in black scales; a similar, fainter, subdorsal streak terminating in black scales at apex of the wing; cilia yellowish gray. Hind

[1] Sometimes bearing minute setæ.

wings dark fuscous with paler cilia. Abdomen reddish brown. Legs (Pl. 8, *D*) light reddish, with black annulations on tarsi and tibiæ.

Male genitalia (Pl. 8, *E*) weakly chitinized; harpes paddle-shaped, strongly haired; margins with row of weak curved spines; sacculus small, slightly haired; tegumen evenly chitinized; uncus moderately long, tapering to a sharp point; ædœagus long, slender, spined; inclosing the harpes ventrally is a large heart-shaped, long-haired, chitinized envelope.

Alar expanse 9 to 12 mm.

FULL-GROWN LARVA.—The full-grown larva is 7 to 8 mm. long, cylindrical, deep wine red. Head light brown, with blackish trophi. Thoracic shield broad, undivided, strongly chitinized, dark brown. Anal plate light brown. Tubercles small, whitish, bearing long, light-brown setæ. Crotches of abdominal feet 20 to 24 in complete circe (Pl. 10, *C*).

PUPA.—The pupa (Pl. 12, *E*, *F*) is 7 to 8 mm. long, light yellowish brown, smooth, with four short setæ on the vertex and six short setæ on the first thoracic segment; two short, paired setæ near the spiracles and four short hooked setæ dorsally on fifth to ninth abdominal segments, two anterior and two posterior on each joint. Anal opening large, slitlike, surrounded by about twelve long, hooked setæ; no cremaster developed; tip of abdomen bluntly rounded, armed with four long and four shorter strong, hooked setæ. Fronto-clypeal suture distinct and abruptly curved upward near median line. Clypeus and pupal eyes distinctly indicated, labrum and mandibles less so; antennæ close together at their tip, reaching nearly to the tips of the wings; wings reaching to posterior edge of sixth abdominal segment. Spiracles small, normal.

SYNONYMY OF PYRODERCES RILEYI WALSINGHAM

Batrachedra rileyi Walsingham (41, 45).
Batrachedra rileyi Howard (42, 43).
Batrachedra rileyi Dyar (44).
Batrachedra rileyi Swezey (46).
Pyroderces rileyi Durrant (47).
Batrachedra rileyi Chittenden (48).

LITERATURE CITED

PECTINOPHORA GOSSYPIELLA

(1) SAUNDERS, W. W.
1843. Description of a species of moth destructive to the cotton crops in India. *In* Trans. Ent. Soc. London, v. 3, p. 284–285.
Original description under the name "*Depressaria gossypiella*," and account of damage done to American cotton grown on light alluvial soil at Broach, India.

(2) ———
1851. Upon the insects injurious to the cotton plant. (Abstract.) *In* Zoologist, v. 9, p. 3069–3071.
Page 3070: *Depressaria gossypiella* mentioned as very destructive to American cotton grown in India, but seldom attacking the native cotton.

(3) COTES, E. C., and SWINHOE, C.
1889. A Catalogue of the Moths of India. pt. 6. Calcutta.
Page 710, species 4900: Record, as *Depressaria gossypiella*, of its occurrence in India.

(4) COTES, E. C.
1893. A conspectus of the insects which affect crops in India. *In* Indian Mus. Notes, v. 2, no. 6, p. 145–176.
Page 163, no. 148: Record of *Depressaria gossypiella* among insect pests of India; quotation from Saunders (1).

(5) VOSSELER, J.
1904. Einige Feinde der Baumwollkulturen in Deutsch-Ostafrika. *In* Mitt. Biol. Landw. Inst. Amani, No. 18, 4 p.
Preliminary account of *Gelechia* sp. in German East Africa. Gives life history, states that the larva leaves the boll for pupation, and recommends light traps, without, however, having tried them.

(6) MEYRICK, E.
1905. Descriptions of Indian Micro-lepidoptera. *In* Jour. Bombay Nat. Hist. Soc., v. 16, no. 4, p. 580–619.
Page 592: As *Gelechia gossypiella;* says the species is a true species of Gelechia and very destructive to cotton in India.

(7) VOSSELER, J.
1905. Bericht des Zoologen. *In* Ber. Land. u. Forstw. Deutsch-Ostafrika, Bd. 2, Heft 7, p. 403–443.
3. Feinde der Baumwolle, p. 407–416: Account of remedial experiments against the pink bollworm (*Gelechia* sp.). Found that, if the gathered infested cotton is spread out on sheets in the sun, the bollworm will leave it and that chickens and ducks would eagerly search for and eat the larvæ which tried to escape the baking sun.

(8) MAXWELL-LEFROY, H.
1906. Indian Insect Pests. 318 p., 346 fig., and fig. A–S.
Pages 93–96, fig. 104–107: Life history of *Gelechia gossypiella.* States that "the moths are attracted to light and readily captured in lamp traps." Recommends as remedies: (1) Plucking off the first crop of bolls and (2) fumigation of seeds to kill hibernating larvæ.

(9) ———
1906. The insect pests of cotton in India. *In* Agr. Jour. India, v. 1, pt. 1, p. 49–61, pl. 6–9.
Life history of the "pink bollworm," *Gelechia gossypiella,* and preventive measures against it. Recommends the picking and burning of all infested bolls of the first crop.

(10) VOSSELER, J.
1906. Arbeiten im zoologisch-entomologischen Laboratorium. *In* Ber. Land. u. Forstw. Deutsch-Ostafrika, Bd. 2, Heft 8, p. 501–512.
3. Feinde der Baumwolle, p. 503–505: Recommends hand picking and destruction of infested bolls.

(11) STUHLMANN, F.
1907. Plauderei über ostafrikanische Baumwolle . . . *In* Pflanzer, Jahrg. 3, No. 12/14, p. 193–224; No. 15/16, p. 225–229.
Pages 216–217: Notes on *Gelechia gossypiella,* "der roter Kapselwurm." States that it is the worst enemy of cotton; notes that the moth is never observed in daytime and is not attracted to light.

(12) VOSSELER, J.
1907. Die Baumwollpflanzungen bei Sadani. *In* Pflanzer, Jahrg. 3, No. 21/22, p. 331–343.
Page 337: Notes on *Gelechia gossypiella,* "der roter Kapselwurm." States that it normally becomes so abundant in two to three years after its introduction in a field as to necessitate discontinuance of the crop.

(13) WALSINGHAM, T. de G.
1907. Microlepidoptera. *In* Fauna Hawaiiensis, v. 1, pt. 5, p. 469–759, pl. 10–25.
As *Gelechia gossypiella.* Bibliography to date; specific description and record of the species; introduction into the Hawaiian Islands; discussion of original home.

(14) BURT, B. C.
1908. Report on the Cawnpore Agricultural Station . . . for the year ending 30th June, 1908. 36 p., App. Allahabad.
Entomological notes, p. 32–36: Species listed as "red bollworm" among insects of the year, with mention of unsuccessful treatment with carbon bisulphid and sulphur dioxid for the destruction of the larvæ in cotton seeds.

(15) GREEN, E. E.
1909. Entomological notes. *In* Trop. Agr. [Ceylon], v. 33, no. 1, p. 34–35.
Notes on injury to cotton bolls by the pink bollworm on the experiment station plots in Ceylon.

(16) FULLAWAY, D. T.
1909. Insects of cotton in Hawaii. Hawaii Agr. Exp. Sta. Bul. 18, 27 p., 18 fig.
Pages 16–21, fig. 9–13: Description and life history of *Gelechia gossypiella,* "the bollworm"; its introduction and spread in the Hawaiian Islands. States that he has bred the species from milo (*Thespesia populnea*); advises as remedies clean culture and cultural methods, destruction of infested bolls by burning, pruning, and burning after the last crop and ginning soon after picking.

(17) MAXWELL-LEFROY, H., and HOWLETT, F. M.
1909. Indian Insect Life. 786 p., 536 fig., 84 pl. Calcutta, London.
Page 180: Records *Apanteles depressariae* as parasitic on *Gelechia gossypiella* in India.
Page 514: Refers to his former publications on the insect.

(18) ZIMMERMANN, A.
1910. Anleitung für die Baumwollkultur in den deutschen Kolonien. Aufl. 2, 159 p., 26 fig. Berlin. Literaturverzeichniss, p. 146–151.
Pages 112–115, fig. 18: Life history of and remedies against "the red bollworm," *Gelechia gossypiella*, in Africa. Quotes from Vosseler; states that the larva leaves the boll before pupation. Also advocates light traps on Maxwell-Lefroy's recommendation.

(19) MCCLELLAND, C. K., and SAHR, C. A.
1911. Cultural methods for controlling the cotton bollworm. Hawaii Agr. Exp. Sta. Press Bul. 32, 8 p., illus.
Recommends annual pruning, clean culture, and trapping of the moths. Observed that Sea Island cotton is more subject to attack than Caravonica and Egyptian and that upland cotton is least attacked of all varieties. Describes and figures a trap lantern which is stated to have been used with good results against *Gelechia gossypiella*.

(20) MAXWELL-LEFROY, H., and HOWLETT, F. M.
1911. Progress of economic entomology in India. *In* 1er Cong. Internat. Ent. 1910, v. 2, Mém., p. 465–482.
Pages 474–475: Bollworms in cotton. Measures of control carried out by the Punjab Agricultural Department.

(21) MORSTATT, H.
1911. Das Auftreten von Pflanzungschädlingen in Deutsch-Ostafrika im Jahr. 1910. *In* Pflanzer, Jahrg. 7, No. 2, p. 65–74.
Page 66: Mentions *Gelechia gossypiella* (der rote Kapselwurm) as being very injurious in all parts of the colony.

(22) ———
1911. Ein Rüsselkäfer an Caravonica-Baumwolle. *In* Pflanzer, Jahrg. 7, No. 4, p. 227–230, pl. 1.
Page 229: Mentions *Gelechia gossypiella* (der rote Kapselwurm) as being very injurious in all parts of the colony.

(23) ———
1911. Saatgut und Vorratsschädlinge und Saatgutdesinfektion. *In* Pflanzer, Jahrg. 7, No. 10, p. 576–604, pl. 9–10.
Page 585, pl. 10, fig. 4: Short description and notes on life history.

(24) ADAIR, E.
1912. [Gelechia gossypiella bred from Thespesia populnea.] *In* Bul. Soc. Ent. Égypte, 1911, fasc. 4, p. 123.
Note stating that *Gelechia gossypiella* has been bred from *Thespesia populnea* in Hawaii. Quotes from Maxwell-Lefroy that the larva of *Gelechia gossypiella* will leave the bolls if these are placed on a cloth in the sun.

(25) ANDRES, Adolf.
1912. Note sur un ravageur de la noix du cotonnier (Gelechia gossypiella, Saund.) nouveau pour l'Égypte. *In* Bul. Soc. Ent. Égypte, 1911, fasc. 4, p. 119–123, 1 fig.
Gives life history of *Gelechia gossypiella* and notes on its occurrence in Egypt, as well as remedial measures used against it there.

(26) DURRANT, J. H.
1912. Notes on Tineina bred from cotton bolls. *In* Bul. Ent. Research, v. 3, pt. 2, p. 203–206, fig. 1.
Gives more important references to previous literature; discusses origin and spread of *Gelechia gossypiella*.

(27) STURM, and ZIMMERMANN, A.
1912. Ueber die Verwendung der Abresch'schen Lichtfalle bei Baumwollschädlingen und Stechmücken. *In* Pflanzer, Jahrg. 8, No. 2, p. 61–65.
Records an experiment with a specially constructed light trap in the cotton fields. Though the result was negative, so far as *Gelechia gossypiella* was concerned, the authors consider it probable that the species is attracted to light.

(28) DUDGEON, G. C.
1913. The pink bollworm. *In* Agr. Jour. Egypt, v. 2, pt. 2, 1912, p. 45–48, pl. 2.
Records the common occurrence of *Gelechia gossypiella* in Egypt for many years. Description and notes on biology. States that he has bred the species from pomegranates.

(29) FULLAWAY, D. T.
1913. Report of the entomologist. *In* Hawaii Agr. Exp. Sta. Ann. Rpt. 1912, p. 16–34, pl. 1.
Pink bollworm of cotton, p. 23–24: Reports cultural methods of control tried in the Hawaiian Islands against *Gelechia gossypiella* only partially successful, one of the experimental fields becoming so badly infested that it was necessary to plow it up and burn it to save adjacent fields. Records additional parasites.

(30) ZACHER, Friedrich.
1913. Die afrikanischen Baumwollschädlinge, unter besonderer Berücksichtigung der von Busse und Kersting in Togo Gesammelten Arten. *In* Arb. K. Biol. Anst. Land. u. Forstw., Bd. 9, Heft 1, p. 121–232, 83 fig. Literatur, p. 230–232.
Pages 199–202, fig. 62: Description and life history of and remedial measures against *Gelechia gossypiella*. States that the species flies to light.

(31) GOUGH, L. H., and STOREY, G.
1914. Methods for the destruction of the pink bollworm (Gelechia gossypiella, Saund.) in cotton seed. (*In* Agr. Jour. Egypt, v. 3, pt. 2, 1913, p. 73–95, pl. 5.
Reports on various experiments in control, the most effective of which were hot air, carbon bisulphid, hydrocyanic-acid gas, sulphur dioxid, and soaking in cyllin solution.

(32) HUNTER, W. D.
1914. The pink bollworm. U. S. Dept. Agr. Bur. Ent. [Circ.], Aug. 7, 1914, 6 p., 5 fig.
Life history and description of *Gelechia gossypiella* and discussion of damage done by it; distribution and food plants of the species and the danger of its introduction into the United States.

(33) WILLCOCKS, F. C.
1914. An acarine parasite of the pink bollworm. *In* Bul. Soc. Ent. Égypte, 1913, fasc. 2, p. 68–72.
Gives life history and number of generations of *Gelechia gossypiella* in Egypt. Mentions the predacious mite *Pediculoides ventricosus* which he has found destroying the larva of *G. gossypiella* but doubts its efficiency in the field. Also mentions a *Pimpla* sp. reared from *P. gossypiella*.

(34) ———
1914. Note préliminaire sur Bracon sp. insecte parasite du ver de la capsule du cottonier (Earias insulana Boisd.). *In* Bul. Soc. Ent. Égypte, 1913, fasc. 2, p. 56–67.
Biological notes on braconid determined as *Rhogas kitcheneri* Dudgeon and Gough; states that it is normally an external parasite on *Earias insulana* Boisd., but that it attacked also larvæ of *Gelechia gossypiella* in the laboratory.

(35) DEAN, W. S.
1916. Manufacturing tests of cotton fumigated with hydrocyanic-acid gas. U. S. Dept. Agr. Bul. 366, 12 p.
Tests with cotton fumigated for the destruction of the pink bollworm (*Gelechia gossypiella*) proving that this treatment does not materially affect the qualities of the cotton.

(36) GOUGH, L. H.
1916. The life history of Gelechia gossypiella from the time of the cotton harvest to the time of cotton sowing. Min. Agr. Egypt Tech. and Sci. Serv. Bul. 4 (Ent. Sect.), 16 p.
A study of the hibernating larva. States that they may live more than two years. Recommends early destruction of the bolls in the field and the killing of the hibernating larvæ.

(37) GOUGH, L. H.

1916. The nature of the damage done by the pink bollworm (Gelechia gossypiella, Saund.). Min. Agr. Egypt Tech. and Sci. Serv. Bul. 2 (Ent. Sect.), 6 p.

Statistics on the amount of damage done by the pink bollworm in Egypt to the seed and to the lint.

(38) ——

1916. Note on a machine to kill Gelechia larvæ by hot air, and the effects of heat on Gelechia larvæ and cotton seed. Min. Agr. Egypt Tech. and Sci. Serv. Bul. 6 (Ent. Sect.), 18 p., 3 pl.

Describes two hot-air machines designed to kill the larvæ of *Gelechia gossypiella* in the cotton seeds without any injury to the seeds.

(39) HEINRICH, Carl.

1916. On the taxonomic value of some larval characters in the Lepidoptera. *In* Proc. Ent. Soc. Wash., v. 18, no. 3, p. 154–164, illus. Bibliography, p. 163–164.

Page 163: Recognizes the epipharyngeal plates of *gossypiella* as modified setæ.

(40) BUSCK, August.

1917. Notes on Parisierola emigrata Rohwer, a parasite on the pink bollworm (Hymenoptera, Bethylidae). *In* Insecutor Inscitiae Menstruus, v. 5, no. 1/3, p. 3–5.

Biology of *Parisierola emigrata* Rohwer, reared from *G. gossypiella* in Honolulu.

PYRODERCES RILEYI

(41) WALSINGHAM, T. de G.

1882. Notes on Tineidæ of North America. *In* Trans. Amer. Ent. Soc., v. 10, p. 165–204.

Page 196; Description of *Batrachedra rileyi*.

(42) HOWARD, L. O.

1896. The insects which affect the cotton plant in the United States. *In* U. S. Dept. Agr. Office Exp. Sta. Bul. 33, p. 317–350, fig. 10–29, pl. 4.

Page 348: *Batrachedra rileyi* is often found in young bolls, and is generally believed by planters to act independently of bollworm damage.

(43) ——

1897. Insects affecting the cotton plant. U. S. Dept. Agr. Farmers' Bul. 47, 31 p., 18 fig.

Page 29: *Batrachedra rileyi* often found in young bolls, and is generally believed to act independently of bollworm damage.

(44) DYAR, H. G., and others.

1902. A list of North American Lepidoptera and key to the literature of this order of insects. Bul. U. S. Nat. Mus. 52, 723 p.

Page 534, no. 6659: *Batrachedra rileyi*.

(45) WALSINGHAM, T. de G.

1906. Description of a new tineid moth infesting cotton-pods in Egypt. *In* Ann. and Mag. Nat. Hist., s. 7, v. 18, no. 105, p. 178–179.

Page 179: Habits of *Stagmatophora gossypiella* similar to those of *Batrachedra rileyi*.

(46) SWEZEY, O. H.

1909. The Hawaiian sugar cane bud moth (Eremotis flavistriata). With an account of some allied species and natural enemies. Hawaii. Sugar Plant. Assoc. Div. Ent. Bul. 6, 40 p., 6 pl.

(47) DURRANT, J. H.

1912. Notes on Tincina bred from cotton-bolls. *In* Bul. Ent. Research, v. 3, pt. 2, p. 207–208, 3 fig.

Gives more important references to previous literature of *Pyroderces rileyi*.

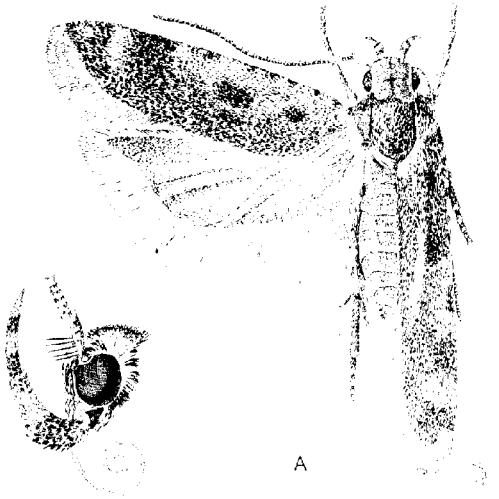
(48) CHITTENDEN, F. H.

1916. The pink corn-worm: an insect destructive to corn in the crib. U. S. Dept. Agr. Bul. 363, 20 p., 7 fig., 4 pl. Bibliography, p. 19–20.

Batrachedra rileyi.

PLATE 7

A.—*Pectinophora gossypiella:* Adult.
B.—*Pyroderces rileyi:* Adult.



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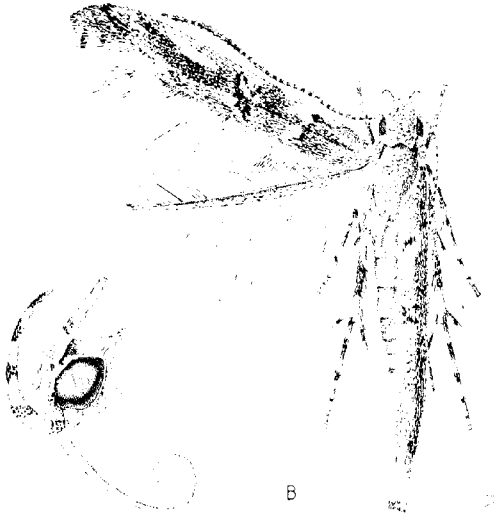

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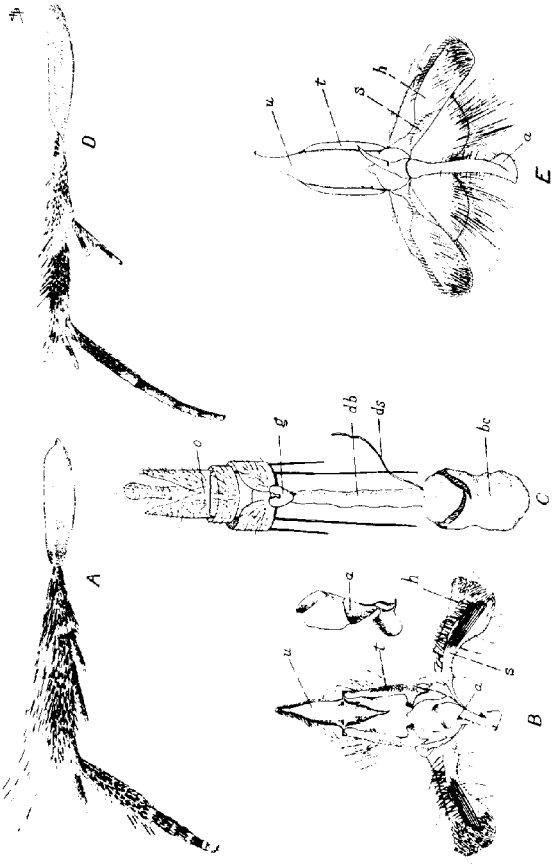
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u

PLATE 8

A.—*Pectinophora gossypiella:* Right hindleg.

B.—*Pectinophora gossypiella:* Genitalia of male. *u*, Uncus; *t*, tegumen; *h*, harp; *a*, ædœagus; *s*, sacculus.

C.—*Pectinophora gossypiella:* Genitalia of female. *o*, Ovipositor; *g*, genital plate with genital opening; *db*, ductus bursæ; *ds*, ductus seminalis; *bc*, bursa copulatrix.

D.—*Pyroderces rileyi:* Right hindleg.

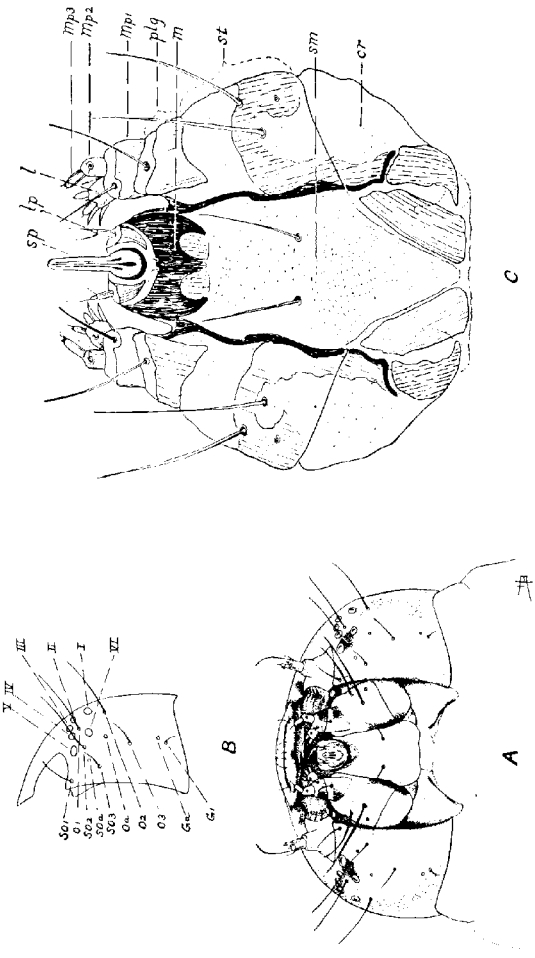
E.—*Pyroderces rileyi:* Genitalia of male. *u*, Uncus; *t*, tegumen; *s*, sacculus; *h*, harp; *a*, ædœagus.

PLATE 9

A.—*Pectinophora gossypiella:* Larval head from underside.

B.—*Pectinophora gossypiella:* Seta arrangement of epicraneum in figure A. *I*, Ocellus i; *II*, ocellus ii; *III*, ocellus iii; *IV*, ocellus iv; *V*, ocellus v; *VI*, ocellus vi; O_1, ocellar seta 1; O_2, ocellar seta 2; O_3, ocellar seta 3; *Oa*, ocellar puncture; SO_1, subocellar seta 1; SO_2, subocellar seta 2; SO_3, subocellar seta 3; *SOa*, subocellar puncture; G_1, genal seta; *Ga*, genal puncture.

C.—*Pectinophora gossypiella:* Labium and maxillæ. *sp*, Spinneret; *lp*, labial palpus; *l*, lacinia and galea; *m*, mentum; *sm*, submentum; *cr*, cardo; *st*, stipes; *plg*, palpiger; mp_1, maxillary palpus, first joint; mp_2, maxillary palpus, second joint; mp_3, maxillary palpus, third joint.


mp3
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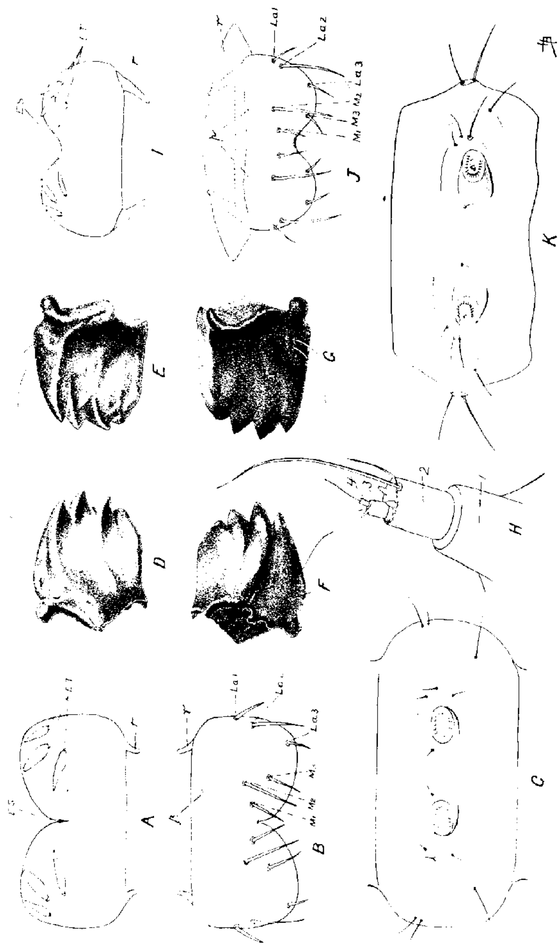

PLATE 10

A.—*Pyroderces rileyi:* Epipharynx of larva. *ES*, Epipharyngeal shield; *ET*, epipharyngeal setæ; *r*, epipharyngeal rod.

B.—*Pyroderces rileyi:* Labrum of larva. La_1, Lateral labral seta 1; La_2, lateral labral seta 2; La_3, lateral labral seta 3; M_1, median labral seta 1; M_2, median labral seta 2; M_3, median labral seta 3; *p*, labral punctures; *r*, epipharyngeal rod.

C.—*Pyroderces rileyi:* Underside of third abdominal segment of larva.

D.—*Pectinophora gossypiella:* Right mandible of larva from underside.

E.—*Pectinophora gossypiella:* Left mandible from underside.

F.—*Pectinophora gossypiella:* Right mandible from upper side.

G.—*Pectinophora gossypiella:* Left mandible from upper side.

H.—*Pectinophora gossypiella:* Left antenna of larva from underside. *1*, First joint; *2*, second joint; *3*, third joint; *4*, fourth joint.

I.—*Pectinophora gossypiella:* Epipharynx of larva. *ES*, Epipharyngeal shield; *ET*, epipharyngeal setæ; *r*, epipharyngeal rod.

J.—*Pectinophora gossypiella:* Labrum of larva. La_1, Lateral labral seta 1; La_2, lateral labral seta 2; La_3, lateral labral seta 3; M_1, median labral seta 1; M_2, median labral seta 2; M_3, median labral seta 3; *p*, labral punctures; *r*, epipharyngeal rod.

K.—*Pectinophora gossypiella:* Underside of third abdominal segment of larva.

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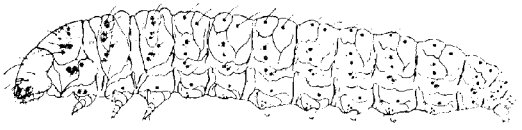
PLATE II

A.—*Pectinophora gossypiella:* Larva.

B.—*Pectinophora gossypiella:* Schematic chart of arrangement of body setæ of larva. *T I*, first thoracic segment; *T II, III*, second and third thoracic segments; *A III*, third abdominal segment; *A VIII*, eighth abdominal segment; *A IX*, ninth abdominal segment; *A X*, tenth abdominal segment.

C.—*Pyroderces rileyi:* Larva.

D.—*Pyroderces rileyi:* Schematic chart of arrangement of body setæ of larva. *T I*, first thoracic segment; *T II, III*, second and third thoracic segments; *A III*, third abdominal segment; *A VIII*, eighth abdominal segment; *A IX*, ninth abdominal segment; *A X*, tenth abdominal segment.



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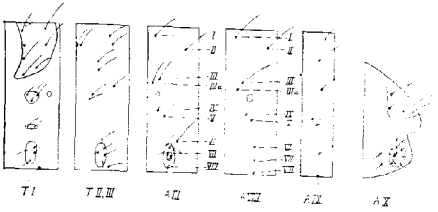

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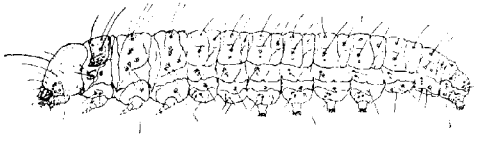

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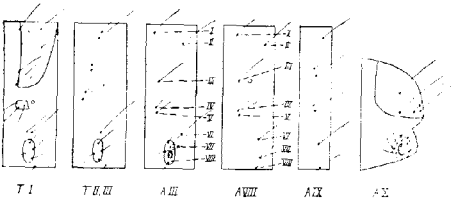

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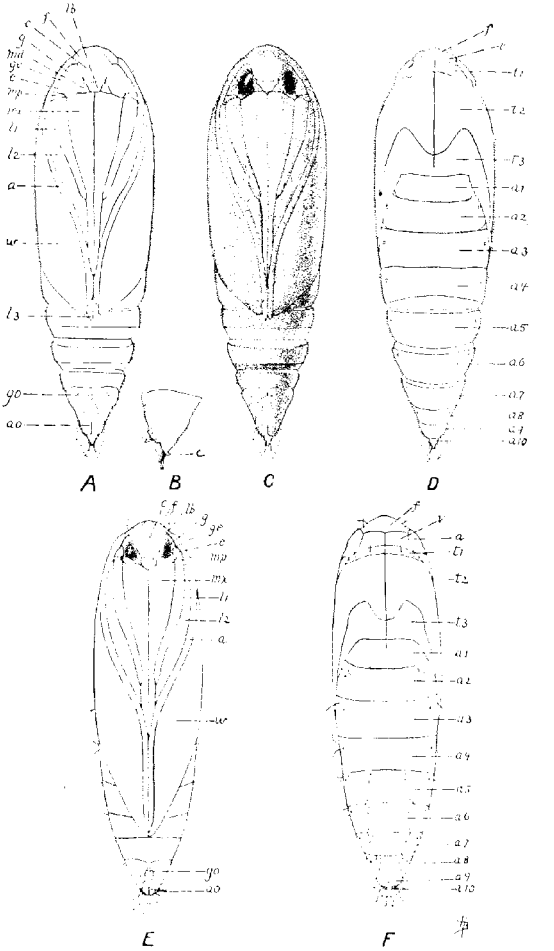
A
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PLATE 12

A.—*Pectinophora gossypiella:* Pupa from front. *lb*, Labrum; *f*, front; *c*, clypeus; *g*, gena; *md*, mandibles; *ge*, glaced eye; *e*, eye; *mp*, maxillary palpus; *mx*, maxilla; l_1, first thoracic leg; l_2, second thoracic leg; l_3, third thoracic leg; *a*, antenna; *w*, forewing; *go*, genital opening; *ao*, anal opening.

B.—*Pectinophora gossypiella:* Tip of pupa from left side. *c*, Cremaster.

C.—*Pectinophora gossypiella:* Mature pupa, with eyes of the imago visible through pupal skin.

D.—*Pectinophora gossypiella:* Pupa from back. *f*, Front; *v*, vertex; t_1, first thoracic segment; t_2, second thoracic segment; t_3, third thoracic segment; a_1, first abdominal segment; a_2, second abdominal segment; a_3, third abdominal segment; a_4, fourth abdominal segment; a_5, fifth abdominal segment; a_6, sixth abdominal segment; a_7, seventh abdominal segment; a_8, eighth abdominal segment; a_9, ninth abdominal segment; a_{10}, tenth abdominal segment.

E.—*Pyroderces rileyi:* Pupa from front. *c*, Clypeus; *f*, front; *lb*, labrum; *g*, gena; *gl*, glaced eye; *e*, eye; *mp*, maxillary palpus; *mx*, maxilla; l_1, first thoracic leg; l_2, second thoracic leg; *a*, antenna; *w*, forewing; *go*, genital opening; *ao*, anal opening.

F.—*Pyroderces rileyi:* Pupa from back. *f*, Front; *v*, vertex; *a*, antenna; l_1, first thoracic segment; t_2, second thoracic segment; t_3, third thoracic segment; a_1, first abdominal segment; a_2, second abdominal segment; a_3, third abdominal segment; a_4, fourth abdominal segment; a_5, fifth abdominal segment; a_6, sixth abdominal segment; a_7, seventh abdominal segment; a_8, eighth abdominal segment; a_9, ninth abdominal segment; a_{10}, tenth abdominal segment.